

Addressing misconceptions of Fast Mapping in adults

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Abstract

Studies of fast mapping (FM) in adults have included both positive results and failures to replicate. I argue that although conflicting studies warrant caution, FM findings are nonetheless promising and intriguing. I separate the issue into distinct questions: whether FM has hippocampal independence, and whether it has unique cognitive consequences. I clarify some misunderstandings, and identify limitations that may contribute to failures to find learning from FM in some amnesic patients. Finally, I argue that the array of behavioral findings in healthy adults is consistent with computational and neural models.

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In a recent review, Cooper, Greve, and Henson (2018) discuss studies of fast mapping (FM) in adults. They comment on potential limitations in studies that have found a distinct profile of learning through FM in amnesic patients and healthy adults, leading them to conclude that evidence for the phenomenon is weak. Is there indeed “little evidence for fast mapping (FM) in adults” as Cooper and colleagues suggest? As Cooper and colleagues discuss, FM has been defined as the cognitive process of identifying a referent for a novel word (e.g., recognizing that an item is being referred to as a 'numbat' while answering a question) or the act of learning this association. Under both definitions, all studies find above-chance performance in healthy adults. As such, rather than asking if adults can fast map, the more central question is whether learning through FM is distinct –neurally and cognitively– from other types of learning.

The interesting question of whether FM is distinct has received affirmative answers from three separate groups (e.g., Coutanche & Thompson-Schill, 2014; Himmer, Müller, Gais, & Schönauer, 2017; Sharon, Moscovitch, & Gilboa, 2011) and null results from three others (e.g., Greve, Cooper, & Henson, 2014; Smith, Urgolites, Hopkins, & Squire, 2014; Warren & Duff, 2014), leading Cooper and colleagues to conclude that there is "little evidence". How should we handle these conflicting findings? I correct several misunderstandings in Cooper et al. (2018) and make broader points on two key questions: (1) Is learning by FM possible without a functioning hippocampus? (2) Do words learned by FM have a distinct cognitive profile? It is important to note that these two questions should not be conflated, as one can be true when the other is not (Coutanche & Thompson-Schill, 2015).

First, can FM occur without a functioning hippocampus? The evidence on whether some amnesic patients can learn more through FM than through explicit encoding is clearly mixed, and this remains an open question. However, it is worth noting concerns with several amnesia studies

reviewed by Cooper et al. (2018), which make the debate about the role of the hippocampus more balanced than the paper suggests. For instance, several amnesia studies that failed to find an FM benefit examined patients with less severe amnesia (in terms of their explicit encoding), compared to studies that found an FM benefit. Two of the three patients discussed in Cooper et al. (2018) are less impaired at explicit encoding than patients that have shown superior learning by FM (compare Cooper et al.'s 67% and 50% explicit encoding performance in a three-alternate forced choice (3AFC) to 31-50% in Sharon et al. (2011) and 10-40% in 4AFC in Merhav et al. (2014)). In assessing reproducibility, it is crucial to compare FM in patients with similar explicit encoding impairments. Under the same goal of comparing similar participants, although healthy older adults are an important group to study for improving learning and memory, their failure to show superior learning through FM (Greve et al., 2014) cannot speak to the necessity of hippocampal involvement. Consider that the hippocampal volume of older adults being tested after FM was still 88% the volume of younger participants (Greve et al., 2014). As a point of comparison, this is a smaller volume difference than has been found between controls and London taxi drivers (who may experience hippocampal growth; Maguire et al., 2000). Additional limitations in prior studies include removing the incidental nature of FM by introducing an experiment to participants as a study of name learning (Warren & Duff, 2014), and having participants 'click on the X', rather than inferring an item's identity by ruling-out a known item (Warren & Duff, 2014; Warren, Tranel, & Duff, 2016). Regarding this last point, although developmental FM studies have included 'click on the X' instructions, it is important not to deviate from the design of a study being replicated. This is particularly true here, where findings have suggested that the inclusion of a known item might be important for some FM effects (Coutanche & Thompson-Schill, 2014). On the other hand, one failure to replicate FM in

amnesia patients does not have the above concerns (Smith et al., 2014), suggesting that some level of caution is certainly warranted. Overall, a more balanced and nuanced perspective is appropriate – findings with amnesic patients are mixed, but not damning. Future research is needed to reach a clear conclusion.

The second question is whether learning through FM has a distinct effect on how new words are incorporated into memory, compared to other paradigms. Here, FM findings from three research groups are consistent with consequences that would be expected from rapid integration into cortical systems (which again does not necessarily require hippocampal independence). Specifically, FM effects on lexical integration (Coutanche & Thompson-Schill, 2014), interference-susceptibility (Merhav et al., 2014), and the impact of sleep (Himmer et al., 2017) follow from the complementary learning systems (CLS) model (McClelland, 2013). These effects are consistent with a body of research showing that related existing knowledge can support rapid neocortical learning (McClelland, 2013). The CLS has been updated in light of such findings to show that "new information that is consistent with knowledge previously acquired by a putatively cortexlike artificial neural network can be learned rapidly" (McClelland, 2013). Behavioral findings that processing related prior knowledge is important during FM (Coutanche & Thompson-Schill, 2014) and the consequences of FM for the impact of sleep (Himmer et al., 2017) and interference (Merhav et al., 2014) fit within this computational framework.

Cooper and colleagues raise several concerns with these behavioral studies: some of which are valid and important, and some that come from inaccuracies, which I now clarify. In describing our 2014 results, Cooper et al. (2018) indicate that "Coutanche and Thompson-Schill's findings suggest that FM only aids lexical integration" (p.11; based on a lack of semantic

priming after FM). In fact, our study did find that FM aided semantic integration, although this priming was apparent the day after learning (Coutanche & Thompson-Schill, 2014). Cooper et al. (2018) also consider our finding that a known item that is atypical for its taxonomic category is particularly effective for eliciting lexical integration (Coutanche & Koch, 2017). Cooper et al. (2018) suggest this conflicts with a prior hypothesis that greater feature overlap between the item being learned, and its accompanying known item, might be beneficial. However, feature overlap and typicality are distinct dimensions. This is apparent if one considers three atypical birds: ostrich, emu, and penguin. The ostrich and emu have many overlapping features (large, wings, long neck), but far less overlap with the penguin (small, flippers, short neck), despite all being atypical birds. For this reason, norming studies frequently measure both typicality and similarity, through participant ratings, among other measures (Ruts et al., 2004). As an aside, it is worth noting that the directionality of this effect (for both typicality and similarity) does not speak to the question of FM's distinctiveness (though does inform our current theories and understanding). Cooper and colleagues also wonder why we did not collapse across typical and atypical trials to test for an overall lexical competition effect. Having chosen items that are very typical and very atypical (and more extreme than in prior work), collapsing makes little sense when one condition is hypothesized to not show an effect. When typicality was more continuous (in a separate dataset), the same relationship between typicality and lexical competition was present (Coutanche & Koch, 2017). Although I have focused here on responses to our own behavioral work, some of the paper's objections to other studies should also be further examined. For example, the authors wonder if *higher* immediate test performance might be an (undefined) "artefactual reason" for greater forgetting in Himmer et al.'s explicit encoding wake group but

suggest *lower* performance might be responsible for greater forgetting in another study (Merhav et al., 2014).

Are the results of these studies all 'perfect and tidy'? Absolutely not. Few behavioral studies give such results. But they do represent findings that are broadly consistent with neural and computational models, with how prior knowledge allows rapid new learning, and with revisions to the CLS model. This consistency provides a promising level of validity. The word 'promising' here is very deliberate – further work is needed to explore the boundaries and parameters of these phenomena. As we do this, it will be important to move beyond an inappropriately coarse expectation that FM, or FM features, should benefit all forms of memory. Indeed, explicit memory retrieval in healthy adults (as tested through AFC) is typically worse after FM than after explicit encoding, so it is not clear why this type of memory retrieval should be improved with certain components of the FM task (the hypothesis tested in Cooper, Greve, & Henson, 2019). A failure of FM to benefit one form of retrieval should not lead to far-reaching conclusions that "there is no evidence that the components hypothesized to be critical for FM are relevant to healthy adults." (abstract, Cooper et al., 2019; e.g., see Coutanche & Thompson-Schill, 2014 for evidence of relevance to healthy adults' lexical competition). FM gives a nuanced pattern of benefits (such as lexical integration) with costs (such as differences in susceptibility to interference). It will be exciting to better understand both the benefits and costs of FM in healthy adults as this research continues.

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